OpenSLAT: Software Tools for Seismic Loss Analysis

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Overview

OpenSLAT is an open-source, object-oriented and extensible extension of the Seismic Loss Assessment Tool (SLAT; Bradley; 2009). Like its predecessor, OpenSLAT is a set of software components based around the Performance-based Earthquake Engineering (PBEE) framework from the Pacific Earthquake Engineering Research Center (PEER). OpenSLAT is written in C++ and Python, and allows users to create projects as C++ or Python programs, or as commands in its own language. OpenSLAT is intended for use by both researchers and practising engineers, and is released under an open-source license to encourage contributions from the user community.

Inputs

OpenSLAT requires data from a number of sources, as shown in Figure 1:

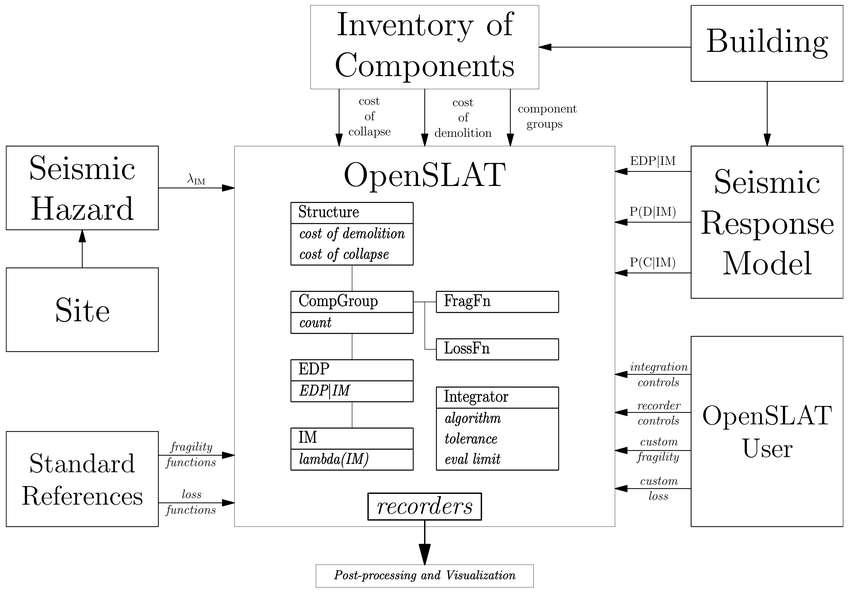

Fig. 1: An overview of OpenSLAT

- **Seismic Hazard** the annual rate of exceedence of some Intensity Measure (*IM*).
- **Seismic Response Model** the probability of demolition or collapse based on *IM*, as well as the relationship between *Engineering Demand Parameters (EDP)*, such as inter-story drift, and *IM*.
- **Inventory of Components** costs associated with repair, demolition, and collapse. For each group of components, we need to know the quantity, which fragility and loss functions describe their behaviour, and which *EDP* they are affected by.
- **Fragility Functions** likelihood of a various levels of damage based on the `EDP`.
- **Loss Functions** repair cost of a component, based on damage state.

Interactions

OpenSLAT is comprised of several software components, as shown in Figure 2:

- `libslat`, a C++ library, is responsible for the most time-consuming calculations. It follows an object-oriented design based on the PBEE framework, and can be use directly from C++. It uses OpenMP for parallel computation, and a caching mechanism to avoid redundant computations.
- `pyslatlib` is a Python library wrapping `libslat`, and including additional convenience classes and functions. `pyslatlib` allows Python programmers to use OpenSLAT alongside all the data structures, control structures, and libraries of Python.
- The **Interpreter** recogises OpenSLAT's own languge, which can be used by non-programmers to write simulations.
- A **Graphical User Interface (GUI)** is planned as a future addition. It will facilitate using OpenSLAT without editing the underlying data files directly.

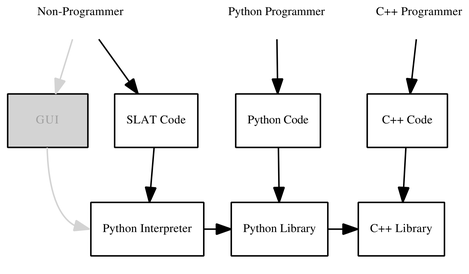

Fig. 2: The components of OpenSLAT

Outputs

OpenSLAT's calculations are based on the PEER-framework formula. OpenSLAT calculates the annual rate of exceedance for loss to the structure (Figure 3a), and also makes intermediate results available:

- **Rate of Exceedence of Demand** depends on the EDP|IM relationship, and the ground motion hazard, λ_{IM} (Figure 3b).
- **Repair, Collapse, and Demolition** OpenSLAT can separate the cost of repair from the cost of demolition and collapse (Figure 3c). As one would expect, the major source of loss at lower intensities is repair, with demolition and collapse becoming more dominant as intensity increases.
- **Deaggregation by Component** OpenSLAT can deaggregate repair cost by component type. For example, Figure 3d illustrates the repair cost of a reference structure, deaggregated by component type. In this case, the relative contribution of each component appears to be fairly fairly consistent over a range of IM values.
- The deaggregated cost at a given intensity can be used to generate a pie chart (Figure 3e), as a different way of presenting the relative contributions to the total loss.
- Figure 3f shows how each EDP contributes to the loss at a specific IM as a vertical bar chart. The EDPs are arranged by building storey, making it easier to see how losses vary with height.

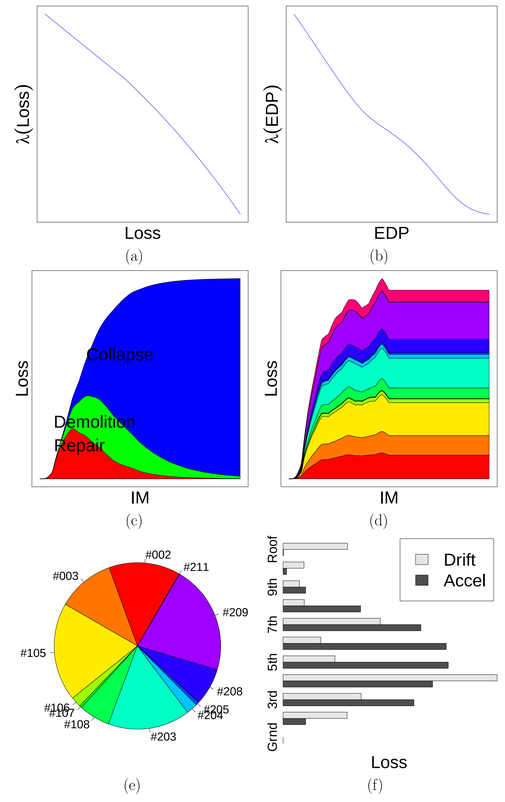

Fig. 3: Graphs of OpenSLAT-generated data.

Future Plans

While OpenSLAT is already useful in its current state, there is much we are currently working on to improve it:

- Add a graphical user interface (GUI), to free users from the need to work directly with SLAT or another programming language.
- Create a database of standard component fragility and loss functions for New Zealand-specific components.
- Improve OpenSLAT's robustness and error reporting.
- Utilize the flexibility and open-source nature of OpenSLAT, but work hand-in-hand with other proprietary software such as SP3 (HBRisk group), as well as regional loss tools such as Riskscape.

Open Source License

OpenSLAT is made avaiable under an open-source license. The source code is freely available from github (https://github.com/openslat/SLAT, or use the QR code at right). OpenSLAT is primariy developed on Linux systems, but can be built and run on any platform supporting a C++ compiler and a Python interpreter. The installation instructions are still a bit sparse; please contact the author for assistance. The OpenSLAT team enthusiastly encourages anyone interested in using or contributing to the project to contact them through the author.